Optical Disc Technology

The Learning Center For Interactive Technology

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OPTICAL DISC TECHNOLOGY

by

Eldon J. Ullmer, Ph.D.
Educational Technology Branch
Lister Hill National Center for Biomedical Communications
National Library of Medicine
Bethesda, MD 20894

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PURPOSE

The Lister Hill National Center for Biomedical Communications at the National Library of Medicine, in keeping with a long-standing commitment to develop and support innovative methods for training health care professionals, conducts research and development in applying computer, audiovisual, and multimedia technologies to health professions education. In this effort, The Educational Technology Branch (ETB) focuses on interactive technology--the delivery of health sciences education through the combined use of microcomputer and optical disc technology. The ETB also operates The Learning Center for Interactive Technology (TLC) as a "hands-on" laboratory where visiting health sciences educators and researchers can explore the nature and application of interactive technology. TLC staff members provide information on equipment set-up and use and in design alternatives for the development of interactive courseware.

In conjunction with this effort, a series of TLC monographs containing much of this information has been created, thereby providing a set of guides intended to introduce the reader to the new world of interactive educational technology.

Michael J. Ackerman, Ph.D.
Chief, Educational Technology Branch

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CONTENTS

INTRODUCTION

Early Development

After Scottish inventor John Logie Baird successfully demonstrated television image transmission using a mechanical scanning disk in 1926, and subsequently devised a means for recording TV signals on a concentric track disk, approximately a half-century would pass before the technological, manufacturing, and marketing developments necessary to make the videodisc a viable instrument for storing, retrieving and dispensing audio and visual information would materialize. Since 1980, enthusiasm for videodisc systems has grown immensely among educators and information management professionals. Indeed, Howsie (1987) has suggested that a person surveying the interactive videodisc literature "could easily conclude that a revolution in education and training had taken place" (p. 5).

Revolutions in education and training are rare, and cautious observers have noted that little credible evidence exists to justify the cost of widespread videodisc adoption. Hannafin (1985) suggested that "the compelling face validity of interactive video appears to have preempted the developmental research needed to validate empirically the instructional effectiveness of the technology" (p. 235). Such research is being done, and at a rate that appears to be increasing as videodisc use increases. That the videodisc and other optical disc technologies are being more widely used is apparent not only in sales figures, but also in accounts that report that the US Military has adopted the videodisc as "its future training delivery medium" (Howsie, 1987, p. 5).

Optical Disc Potential

That many would be attracted by the optical disc's "compelling face validity" is understandable. The basic technological process that it employs, the precision engineering it embodies, its enormous information storage capacity, its rapid information access capabilities, its quality sound and video reproduction capability, and its interactive features combine to make optical disc technology intriguing. But interest has progressed far beyond mere fascination with the machine. The optical disc's potential as a means for storing and managing

information, for facilitating the design and delivery of instruction, for conducting research to compare alternate instructional strategies, and for introducing lasting innovations in teaching has caught the imagination of many professional educators. Health professions education, where many innovative instructional programs have been developed, is certainly one beneficiary of this initiative.

Technological Advances

This increasing interest in optical disc technology and its potential has underscored the need for professionals in information-based fields to become familiar with this new media "family" and its underlying technology, which involves recognizing the differences between optical and magnetic disc systems, between analog and digital technology, between reflective and transmissive discs, between consumer and industrial machines, and between "intelligent" and "dumb" systems. The fact that optical disc technology, far from standing still, has changed radically in the last few years only complicates this undertaking. Advances in digital technology, for example, have resulted in a new family of "compact disc" (CD) machines, including compact disc-digital audio (CD-DA), compact disc-read only memory (CD-ROM), and compact disc-interactive (CD-I), and in new approaches to implementing multimedia capability in personal computers, such as digital video interactive (DVI).

Optical disc systems, when combined with modern microcomputers, present educators with powerful new tools for making instruction both more individualized and more effective. Thus understanding these new technologies, making wise purchasing decisions, learning how to use interactive video effectively, and documenting effective use through rigorous research are problems that now confront educators who seek to improve instruction through technology. This report is intended as a resource for educators and others engaged in this effort.

OPTICAL DISC DEVELOPMENT CHRONOLOGY

1926	In England, J.L. Baird demonstrates a mechanical scanning system for video image transmission. BBC initiates experimental broadcasts to be received by Baird "Televisors." In the 1930's, Baird's "Phonovision" disk enables broadcast of electronically reproduced video images.
1947	Invention of the transistor.
1956	Introduction of videotape technology.
1958	D.P. Gregg develops idea of recording audiovisual information on a plastic disk as a series of pits to be read by optical means and coins the term "videodisk."
1958/59	Development and introduction of integrated circuits.
1961	3M and Stanford Research Institute (SRI) launch joint research program.
1962	SRI team demonstrates photographic film based videodisc.
1963	3M team demonstrates electron beam recording videodisc.
1970's	MCA, Philips and Thomson-CSF pursue independent videodisc development programs.
1980	LaserVision format videodisc introduced.
1982	Audio compact disc introduced by Philips/Sony.
1982	RCA's David Sarnoff Laboratories begin research on interactive digital video technology.
1982	Sony announces first computer designed for interactive video control applications.
1983	Panasonic introduces Optical Memory Disc Recorder, an analog video, digital audio, "write-once" system.
1984	Optical Disc Corporation introduces the Recordable Laser Videodisc, first LaserVision compatible recordable unit.
1985	Compact-Disc, Read Only Memory (CD-ROM) introduced.

Figure 1.

1986	McDonnell Douglas introduces LaserFilm, an optical, transmissive, photographic process player.
1986	Teac introduces "write once" Optical Videodisc Recorder.
1986	Philips and Sony announce Compact Disc-Interactive (CD-I) specification.
1986	IBM introduces InfoWindow touchscreen display system.
1987	General Electric introduces Digital Video Interactive after acquiring the technology from RCA.
1988	Erasable/Rewritable CD drives introduced.
1988	N.V. Philips displays prototype professional CD-I player system.
1988	Intel acquires DVI technology from General Electric and later introduces application development platform.
1989	Pioneer and KDD introduce first rewritable, analog videodisc system.
1990	Panasonic introduces rewritable, analog videodisc.
1990	Pioneer introduces multifunctional magneto-optical rewritable and WORM optical disk drive.

Figure 1 (continued).

I. VIDEODISC TECHNOLOGY AND FORMATS

After Baird's attempt to market his primitive videodisc system in England during the 1920's failed, little significant developmental work was done until after 1956 when the first successful videotape technology was introduced. According to Jarvis (1988, p. 15), D. Paul Gregg, an engineer who worked for both Ampex and Westrex in the late 1950's, deserves the major credit for inventing the laser videodisc and for first using the term "videodisk" in 1958. Gregg, Jarvis explains, was able to develop an optical means of recording motion images and sound on a disc by combining the concept of FM video recording, used in Ampex videotape machines, with the stereo record/playback system developed at Westrex. Gregg subsequently joined the 3M company which, in association with the Stanford Research Institute (now SRI International), launched a sustained research program in the early 1960's (see Rice and Dubbe, 1982). By the early 1970's, N. V. Philips, Thomson-CSF, and MCA each had developed systems that employed laser light sources to record and play video images (p. 283). When videodisc systems became commercially available in the late 1970's, four different system formats based on two fundamentally different technological designs appeared.

Two Technologies

The two distinctive technological approaches were called <u>optical laser</u> (or optical) and <u>electrical capacitance</u> systems. Both employ the same basic principle to store information; etching millions of tiny computer-produced indentations (called pits) into the surface of a disc (Mann, 1981). The configuration of this sequence corresponds to the PCM (pulse code modulation) version of the normal FM (frequency modulation) video signal. The difference between the two technological approaches lies in the way the discs are recorded and read for playback.

Capacitance Videodiscs

Electrical capacitance videodiscs never achieved significant status in the United States, either for entertainment or for professional uses. One format, the capacitance electronic disc (CED), was developed by

RCA as an entertainment medium and disappeared from the market in 1984. Like the common phonograph record, it employed a grooved disc and a stylus. Unlike the phonograph, however, the disc, while spinning at 450 rpm, was flooded with electricity and, as the stylus rode over the pits in the disc's groove, variations in the electric current enabled reconstruction of the PCM/FM signal needed to reproduce a program. This mode of play prohibited random-access and other multispeed functions and so the CED system's abandonment is not altogether surprising.

The second electrical capacitance videodisc system is the video high density (VHD) format. This format is known as grooveless capacitance because the disc is not grooved; playback involves a mechanical stylus which, instead of riding in a groove, is guided over the disc's surface by a signal that is distinct from the program signal. The VHD format employs a 10.2 inch diameter disc which rotates at 900 rpm during play and provides one hour of motion video or 108,000 still frames per side. The system offers random access, freeze-frame, slow motion and fast scan functions. As with the CED format, marketing of the VHD format in the United States was discontinued some time ago. Thus, for all practical purposes, the optical laser videodisc has become the "industry standard" among professional and home users alike.

Figure 2. A LaserVision Model Videodisc Player (Courtesy of Pioneer Electronics Corporation)

Optical Laser Videodiscs

Optical videodisc systems have been developed in two formats. Both employ a laser beam to read information encoded on the disc. In one format, called reflective, the laser's light is reflected off the disc's surface. The other format, called transmissive, uses a transparent disc and, during play, light is beamed through the disc.

Reflective Discs

When a reflective disc is played, the light beam is reflected strongly by the disc's normal surface. However, each time the beam passes over a pit the light is scattered and only weakly reflected. A photodiode senses these strong and weak reflections as on and off signals and transforms the signal pattern it receives into electrical waves which correspond to the original PCM/FM signal used to etch pits on the disc. This signal is then fed into a television set which recreates the recorded program.

Because nothing comes in contact with the disc during play, and also because of the disc's protective coating, no wear occurs and the useful life of the disc is virtually infinite.

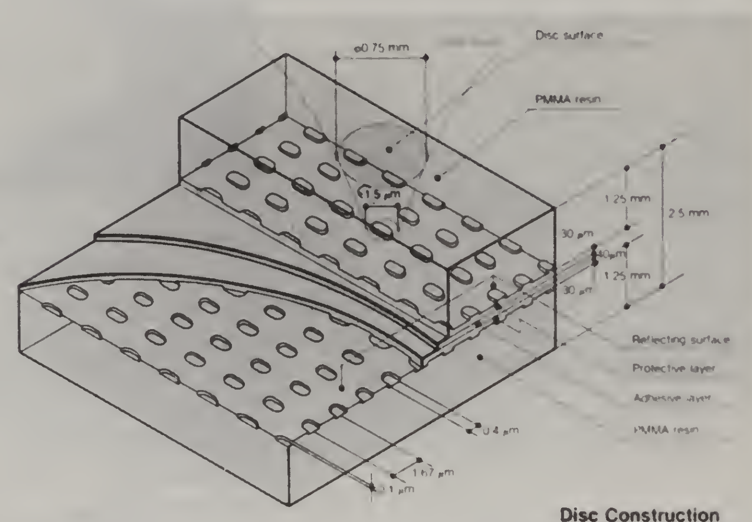

Figure 3. Close-up of Videodisc Construction (Courtesy of Pioneer Electronics Corporation)

The standard reflective optical disc is twelve inches in diameter, although there is also an eight inch version. A twelve inch constant angular velocity (CAV) disc, which rotates at 1800 revolutions per minute, provides

30 minutes of linear play or 54,000 still frames per side. An "extended play" option allows one hour of linear play or 108,000 still frames per side. This is achieved by using a variable rotation rate feature--from 1800 to 600 rpm--which gives the disc a constant linear velocity (CLV). Many late model players can play both CAV and CLV discs; however, functions such as random access, still-frame and slow motion are generally not possible in the CLV mode.

Reflective format videodisc players are widely referred to by the tradename LaserVision, and marketing firms include Pioneer, Sony, Philips and Hitachi.

Figure 4. Videodisc Control Keypad (Courtesy of Sony Corporation)

Transmissive Discs

In 1986, McDonnell Douglas Electronics Company introduced its LaserFilm system, which is now the only transmissive optical system on the market. (An earlier transmissive player was previously marketed by Thomson-CSF.) Whereas LaserVision technology involves computer-activated etching of pits into a shiny, hard disc, the LaserFilm system employs a photographic process in which the video information is placed on a transparent film disc as a sequence of dots. This process provides a disc capacity of 32,400 still frames or 18 minutes of motion video.

As one might suspect, duplication processes for the two systems differ markedly. LaserVision discs are produced

by injection molding. LaserFilm copies are made by photographic processes, a technique for which the manufacturer claims both lower mastering and duplication costs. (Additional information concerning disc production is presented later in this monograph.)

Videodisc Display and Interaction Features

The videodisc's storage capacity is truly amazing, but it is the videodisc display system's presentation and interaction capabilities that fascinate prospective users. Videodiscs can alternate between normal video and still images, over which computer-generated text screens and graphics can be superimposed. Other useful features found on most videodisc systems include random-access, freeze-frame, slow motion, fast scan, reverse motion and interrupt motion. With the appropriate courseware, capabilities such as branching based on performance, and test scoring are possible. Such functional capabilities heighten the videodisc's potential as an educational medium and challenge educators who seek to exploit that potential to improve learning. The specific set of programming functions available with any given system is determined by the hardware configuration and the authoring tools that are chosen.

To explain the videodisc's varied information presentation and control capabilities, a classification scheme which defines "levels" of interactivity has been devised. A <u>Level I</u> system requires only a videodisc player and a television monitor. Since it has no "memory" or "processing power," the system is limited to linear play altered only by the basic <u>pause</u>, <u>search</u> and <u>stop</u> commands built into the player. (Note: There are printed references to a <u>Level 0</u> category to refer to machines that are essentially limited to linear play.)

A <u>Level II</u> system is one in which the videodisc player has a built-in microprocessor with programmable memory. The control program is recorded on one of the audio tracks of the videodisc and is loaded into the player's memory when the disc is used, a process commonly referred to as a "digital dump." Level II players allow for some branching and learner response-feedback cycles within the program control mode, but this capability is quite limited because of the modest memory capacity of the typical Level II machine.

A Level III system employs a microcomputer with a videodisc player to provide significantly increased presentation and interaction capabilities. This combination allows for extensive branching and learner response analysis. Sophisticated information displays are possible since computer-generated text and graphics can be superimposed over regular video images. Programs required to provide this level of flexibility are stored on the computer's disk and must be loaded into the computer's memory. Optional input or interface devices commonly used in Level III systems include keyboards, touchscreens, mouse units, light pens, and barcode readers.

Some new interactive video systems--such as the Sony VIEW System and others to be discussed later--provide Level III capability in a single, integrated unit.

A Level IV videodisc system embodies all the capabilities of Level I, Level II and Level III discs, but is distinctive in several critical respects. The control program is not stored on a computer disk, as in a Level III system, but instead is recorded on the laser disc itself, as with Level II discs. With Level IV discs, however, the digital information constituting the disc control program is encoded in the video field, not in an audio track. Also, computer graphics and still-frame audio information must be stored as digital data in the video field, as well. Thus, whereas Level II play involves "dumping" the control program into the player's memory, in Level IV it is downloaded into a separate computer's memory, making the system operable without the need of an auxiliary computer disk. Consequently, the videodisc player/computer tandem used in a Level IV system must have the capability to recover digital data from a videodisc and decode that data as either control information, graphics, or still-frame audio. As with Level II, program packaging and use with Level IV is simplified since both subject matter content and control information are stored on a single disc. There is no floppy disk to be lost, stolen, or mutilated. But it also means that the control program recorded on the videodisc cannot be modified, as one stored on a computer disk could be.

Levels of Interactivity

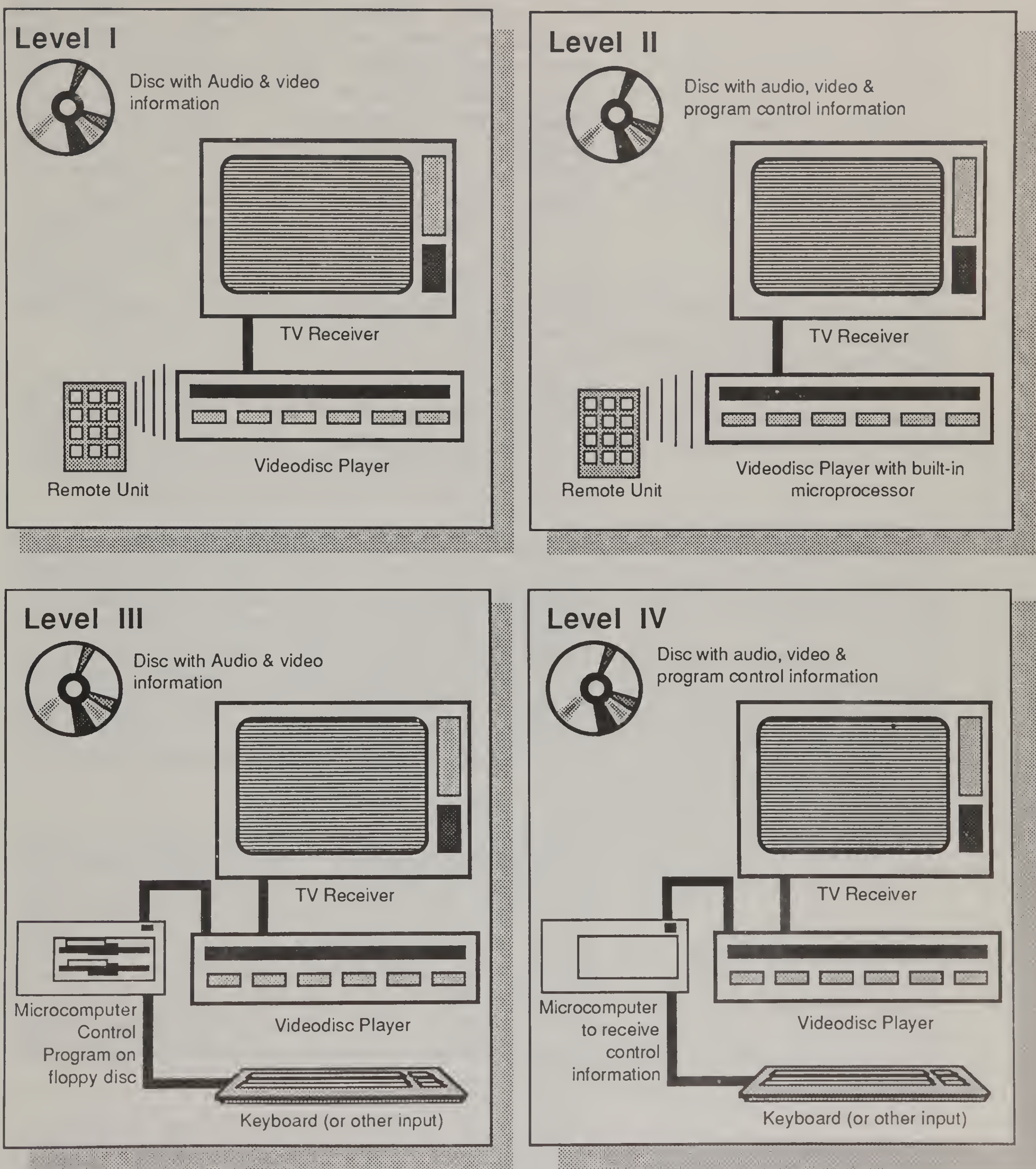

Figure 5.

Audio and Interactive Videodiscs

As prescribed by the National Technical Standards Committee (NTSC), the video picture seen on television sets in North America is composed of thirty still pictures, or frames, per second. The standard NTSC videodisc's 54,000 frame capacity therefore can provide either 54,000 "stills" or 30 minutes of continuously running video. In practice, a typical instructional videodisc is a mix of still frames and motion sequences. Using only a fraction of the disc's total capacity for still-frame displays enables the lesson designer to incorporate many branching opportunities for learners of different knowledge levels and learning styles. However, the teaching effectiveness of still-frame displays is, in large measure, dependent upon providing relevant audio accompaniment.

A videodisc has two audio tracks which, taken together, provide for sixty minutes of audio information, but only in the linear play mode. Thus designing videodisc systems that provide adequate audio with still-picture displays has been a major technical challenge.

One way to add substantial audio capacity to a videodisc system is to digitize the audio signal and store it on a peripheral device, such as an audio compact disc or a computer hard disk. But this means that the peripheral equipment, including suitable control devices, must be added to the instructional system, a cost and operational drawback. Also, storing the digital data presents another problem since an hour of low quality digital audio requires almost all of a 30 megabyte hard disk.

Compressed Audio

What many see as a more promising approach involves using "compressed audio." This technique allows the audio signal to be compressed, converted into a video signal, and stored as a video frame on the disc's video track. In a typical system, each video frame of a disc can store about four seconds of audio data, and thus a standard videodisc has a potential capacity of about 60 hours of audio. This allows programs that include several thousand still frames, each with extensive audio accompaniment, to be produced.

Although the recording process is quite expensive, a little arithmetic clearly demonstrates the advantage of this technique for information delivery. If a designer

wishes to provide 12 seconds of audio for each still frame, the audio information will require three frames (12/4). Adding one frame for the video signal gives a total of four frames used for each still image. Then, if half of a disc is devoted to motion video (15 minutes) and the other half to still images, space for 6,750 still-frames (54,000/2/4) with accompanying audio is available. Needless to say, this capability provides program designers with enormous flexibility in creating instructional programs for many types of learning applications.

The LaserFilm disc, if used in this manner, would provide about 4,050 still frames with audio. The LaserFilm player was designed with built-in compressed audio circuitry, a feature not found on most LaserVision players until recently. Some advanced model LaserVision players now provide compressed audio capability, and it is a basic requirement of the Army's EIDS system.

Recordable Videodisc Technology

Recordable videodisc systems are becoming increasingly popular because they enable a user to record a playable videodisc without going through the expensive and time consuming process of creating a "master disc" from which replicas can be made. This technology is usually referred to by the term DRAW, for Direct Read After Write. A DRAW disc may represent a stage in the standard videodisc production process; in this case it is commonly referred to as a "check disc" because its principal use is for checking the disc's format and content before the master copy is made. But DRAW discs have other uses, as well: low volume production; as an editing tool; and for use in training courses where immediate playback is a necessity.

The recording process for a DRAW disc is similar to that used for producing a standard disc. Audio and video information is encoded as a PCM/FM signal which activates a blue argon laser which does the "writing" on the disc's surface. The data track is a series of pits etched either in spiral fashion or as concentric circles from the inside to the outside of the disc. When the disc is played, the sequence of pits and non-pits, which is the physical representation of the disc's

information, is "read" by a red helium-neon laser in the manner common to other reflective optical videodiscs.

Videodiscs produced with DRAW technology generally do not have the image quality of a "standard" disc, that is, one duplicated from a master. Thus the principal advantages a DRAW system offers to an organization lie in the real time recording and continuous updating capabilities that the technology affords.

Figure 6. Optical Disc Recorder
(Courtesy of Panasonic Industrial Company)

Recordable, "write-once" videodisc systems are now available from several firms. Optical Disc Corporation introduced its Recordable Laser Videodisc (RLV) model in 1984, calling it the first "LaserVision Standard compatible optical medium." Later, the company announced a new disc design (the Mark II) which, it claims, offers significant improvements in recording and playback quality. Panasonic now markets its Optical Memory Disc Recorder (OMDR) in eight and twelve inch disc sizes. The original eight inch disc provides about 13 minutes of motion video. The twelve inch disc is a cartridge unit that is available in single-sided and double-sided models. Recording is possible in two

modes. Normal mode allows 30 minutes of motion video or 54,000 video frames per side, and a Hi-Resolution mode allows 20 minutes of motion or 36,000 still frames. The Panasonic recorders are not LaserVision disc compatible, however. Discs must be played on a Panasonic machine. TEAC Corporation of America introduced its LV-200 series recordable system several years ago, calling it "the first desktop 12-inch videodisc recorder." Upgraded models, the LV-210A videodisc recorder and LV-210P player were introduced in 1989. With a double-sided, CAV disc, up to 108,000 color still pictures or one hour of linear video can be recorded. The Teac player must be used for playback, and several playback functions are offered, including normal speed, variable speed, step and scan playback. Teac also offers a high resolution videodisc recorder, the LV-250HC, which offers over 400 lines horizontal resolution. In 1989, Sony Corporation introduced a "write-once" videodisc recording system that employs "component recording video" technology to provide a capacity of up to 43,500 still pictures or 24 minutes of motion video on one side of the disc. The system includes two components, the LVR-5000 laser videodisc recorder and the LVR-5000 videodisc processor.

Figure 7. Computer Controlled Image Storage System Using an Optical Disc Recorder/Player (Courtesy of Panasonic Industrial Company)

Rewritable Videodiscs

Until recently, the one missing format among optical disc systems was the rewritable, analog videodisc. In October, 1989, however, Pioneer and Kokusai Denshin Denwa Company, Ltd. announced a jointly-developed rewritable magneto-optical videodisc unit that can store a full 30 minutes of motion video in analog format, reportedly the first system with this capability (Joint Development, 1989, p. 1). It is not yet commercially available, however. Panasonic, in April, 1990, introduced a rewritable videodisc recorder, the LQ-4000, which is expected to be available later in 1990. In "normal" recording mode using a two-sided disc, 108,000 still frames or 60 minutes of full-motion video can be stored. A higher resolution mode, with somewhat less storage capacity, is also offered (Panasonic Announces, 1990, p. 1).

Recordable disc systems that employ digital technology and "compact disc" formats will be discussed in the next chapter.

II. DIGITAL OPTICAL DISC SYSTEMS

Three Digital Technologies

Since 1982, when compact disc audio players were introduced, the "CD family" has grown by several members and, although some formats are aimed primarily at the consumer market, it appears that digital optical disc technology holds much promise for educational and information management applications. Thus the distinction of "consumer" versus "educational" or "industrial" models that was applied to the videodisc also applies to the compact disc. In fact, the number of compact disc formats already available probably exceeds the number of different videodiscs remaining on the market. Moreover, these varied formats exist in three fundamentally different technical categories: those that are indelibly pressed for "read-only" playback, the "write-once" group, and the "erasable" systems. The indelible discs, whether used for music, publishing or multimedia applications, generally employ the 4.72 inch disc that the audio CD made commonplace. Other systems use a slightly larger disk that, like the familiar computer "floppy disk," is 5.25 inches in diameter, and is usually spelled with a k. And, some systems use larger discs to increase data capacity, but the important differences do not lie in disc size, or in spelling, but in the technology and its utility.

The major 4.72 inch disc systems all share certain basic technical characteristics: all are reflective laser, optical disc systems; all use digital technology to encode audio and video information on the disc; all are constant linear velocity (CLV) players; and, generally, all follow the "High Sierra" standards (named for a Lake Tahoe hotel at which an ad hoc standards group first met in 1985) for compact disc hardware and software configuration. Another significant commonality of this group is that all exemplify media in which information is indelibly recorded and discs are replicated for wide distribution through a pressing process. The distinctive uses made of these systems, however, reflect the major technological differences among them.

Three CD Formats

In addition to the consumer audio compact disc, there are three compact disc formats that appear to hold

considerable potential for education and other professional applications. These are Compact Disc-Read Only Memory (CD-ROM), Compact Disc-Interactive (CD-I) and Digital Video Interactive (DVI).

The other two groups, the "write once" and "erasable" units, are, by nature of their technology, not practical for wide distribution applications. Their value lies in "local" record keeping or other applications that require frequent updating of information.

Compact Disc-Digital Audio

The compact disc-digital audio (CD-DA) player was introduced in 1982 by Philips and Sony as a high quality sound medium for home use. It's vigorous sales performance since then prompted one writer to label its introduction as "the most successful in the history of consumer electronics" (Sayers, 1987, p. 4). The significance of the music CD to consumers is that it provides up to 72 minutes of 2-channel audio on a disc that cannot be erased and that will not wear out from repeated playing. The optical disc industry recognized a potential compatibility problem early on and made all audio CD systems conform to the so-called "Red Book" standards that Philips and Sony had established. More significant was the recognition that the CD format offered the potential to store and distribute enormous quantities of data on a single disc, and, also, that it might serve as a platform for developing moderately priced multimedia systems. Consequently, from a professional viewpoint, the two major developmental thrusts within the compact disc family have been the development of the CD, first, as a "publishing" medium and, second, as an interactive, multimedia technology.

Compact Disc-Read Only Memory

The only compact disc technology that has a moderately lengthy history of professional application is CD-ROM. Briefly stated, CD-ROM is a read-only, mass information storage and retrieval device that functions as a computer peripheral. The format was introduced in 1985 by Philips and Sony, who published the relevant standards in the so-called "Yellow Book." This standard has been adopted by the International Standards Organization as ISO-9660.

The CD-ROM's data track is one continuous spiral, about three miles long, beginning at the center of the disc. As the optical head moves from the inner tracks to the outside of the disc, the rotation varies from about 500 revolutions per minute to about 200 to maintain a constant linear velocity. The track is divided into "sectors" of either 2048 or 2352 bytes of data capacity. Each sector has a specific location on the disc and, to facilitate access, its own unique address.

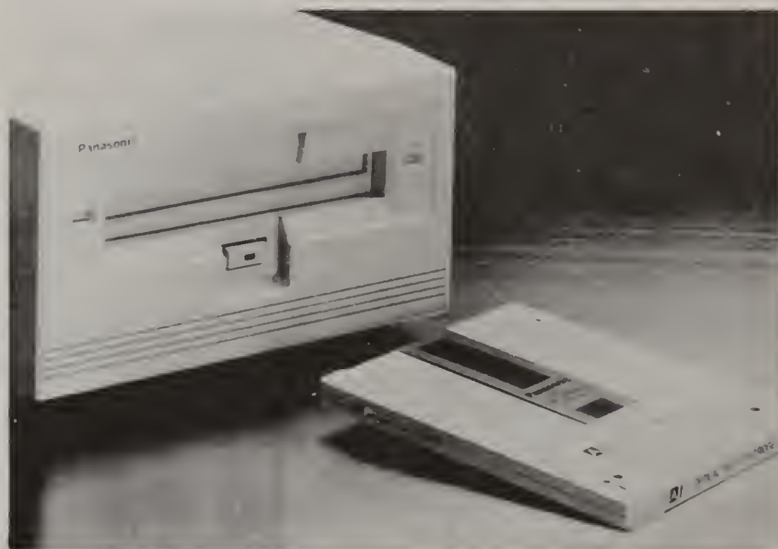

Figure 8. A WORM Optical Disc Drive (Courtesy of Panasonic Industrial Company)

The CD-ROM's application value is manifest in two simple specifications: The disc can hold from 550 to 640 megabytes of data and, under control of a computer, retrieval access time is normally two seconds or less. This storage capacity is the approximate equivalent of 1,500 floppy discs or 250,000 typewritten pages. But there are other advantages, as well. In addition to its high capacity, a disc is light-weight, lasts indefinitely, and cannot be erased accidentally. Moreover, CD-ROM is a "pressable medium," which means that it can be easily and inexpensively replicated.

The medium's flexibility to serve different database and archival applications, according to the setting and associated computer software, makes it a tool with potentially wide usage in business, education and library operations.

Many of the early CD-ROM offerings exemplify what is commonly called a "conversion product," that is, one in which an existing item, such as an encyclopedia or the Physician's Desk Reference, is transferred to disc storage. Typically, these products incorporate only text and data. But increasingly it has been recognized that many of these information collections would benefit greatly if sound, graphics or still pictures could be included. Enter CD-ROM XA (XA for extended architecture). In mid-1988, specifications for an extended CD-ROM format that includes audio, screen resolution, and color coding standards were developed jointly by Philips, Sony and Microsoft. One expectation is that the availability of sound, graphics and still images in an extended CD-ROM format will have major implications for education and training.

Compact Disc-Interactive

Compact Disc-Interactive (CD-I) was announced in 1986 by Philips and Sony as a digital, optical format medium intended to integrate audio, video, text, data and drawings on a single disc. The international standards for CD-I, published in what is called the "Green Book," specify audio and image capabilities for the format and specifically state that CD-I players must have a Motorola 68000 series microprocessor running a CD-RTOS (compact disc-real time operating system), also known as OS/9, so that it operates as a "stand alone" unit. This means that all information for audio, video, text and program code can be stored on a single disc.

Compact Disc-Interactive was designed as a single player system that incorporates all the hardware and software necessary to play back the varied mix of optically recorded information that a CD-I disc might contain. The disc is physically the same as that used with CD music players and CD-ROM drives and it can contain either 72 minutes of high quality stereo digital audio or up to 650 megabytes of data. In a multimedia application, which, of course, is the medium's prime purpose, the actual available capacity will be a function of the trade-offs between the relative amounts of text, graphics, audio and video used, and the quality of audio and visual information that is desired. The 1989 "industrial version" CD-I system provides four levels of audio quality. They range, in playing time, from 72 minutes of stereo CD quality audio to nearly nineteen

hours of monaural voice quality audio. Three video quality options are provided, which range from a low resolution of 384 x 280 pixels to a high resolution of 768 x 560 pixels. Full motion capability on this model was limited to an area of about half the screen size. Consequently, a major technological goal of CD-I's developers has been to provide full screen, full-motion video of acceptable quality for both consumer and professional users. In mid-1989, Philips and Sony announced that full-screen, full-motion capability would become available in 1990.

As the existence of twin systems implies, CD-I is intended to serve both as a home information and entertainment system, and as a professional tool for education and other information dissemination uses. Backers of CD-I are promoting it as both a "new publishing medium" and as a multimedia medium. When used as a publishing medium, it is essentially an extension of the CD-ROM format. A multimedia CD-I application, however, can, in form, mirror an interactive videodisc with which, for example, medical students could learn diagnostic procedures by interacting with an instructional program.

The central unit of the CD-I player system is called the Multimedia Controller. It performs all signal processing and system control functions and operates in tandem with the CD-I player module. CD-I offers two "full planes" and two "auxiliary planes" of video which allows various special effects, including fades, curtains and dissolves. A standard TV monitor may be used for display.

Shipment of commercial CD-I units began in 1989 and, as mentioned, full-screen, full-motion systems will be available later in 1990. Another significant development, especially from a marketing standpoint, is the fact that Sony and Matsushita have joined Philips in supporting the CD-I format. American Interactive Media, a Los Angeles-based software publishing firm, has announced a number of titles under development in the CD-I format (American Interactive Media, 1989).

Digital Video Interactive

While the CD-I format was evolving from a specification to a working system, a technology called Digital Video

Interactive (DVI), originally intended for use with the CD-ROM, was introduced in March, 1987. DVI technology was developed at the David Sarnoff Research Center (formerly RCA Laboratories) in Princeton, New Jersey, was acquired by the General Electric Company in 1986, and in October, 1988, was acquired by Intel Corporation, which has carried out an aggressive research and promotion effort since then.

DVI was developed to be compatible with the CD-ROM "Yellow Book" standard, and by employing sophisticated data compression and decompression techniques, DVI can offer up to 72 minutes of full-motion, full-screen digital video from a standard CD-ROM configuration disc. It is not strictly a CD-ROM technology, however, as other digital devices, such as a large capacity hard disk, can be used as storage media.

Although the first-version DVI system was seen by many as a breakthrough in compact disc technology, the data compression-decompression process it used resulted in a video picture of relatively low resolution. This, of course, is a significant factor in some teaching applications, especially in the health sciences. On the production side, the cost of encoding an original disc was very high. A regular television signal contains about 500 kilobytes of information per frame, which was compressed to about 5 kilobytes per frame, a 100:1 compression ratio. Originally this process required a great deal of computer time--about 30 seconds per video frame using a VAX 8800 computer. These historical notes illustrate the central technological challenge that all developers of digital multimedia systems face: providing high resolution images, and high capacity digital image data storage, at reasonable cost. Thus it is in the area of signal compression/decompression schemes that the major battle for supremacy in producing these systems is being fought.

A brief explanation shows why this is the case. A standard full-motion television picture displays 30 frames per second. When a video image is converted into digital form, at 512 by 480 pixels, it requires about 750 kilobytes of data. This means that the enormous storage capacity of a CD-ROM disc, over 640 megabytes, converts to only about 30 seconds of digital video. Moreover, because a CD-ROM has a "data delivery

speed" of 150 kilobytes per second, it is too slow to display video at "real-time" speed. It would take about five seconds to display a single video frame, and more than an hour to show 30 seconds of digital video. Thus a high degree of compression is necessary, and a significant amount of computer power is needed to achieve it. Thus for DVI application development, an advanced parallel-processing computer is used to reduce compression time for motion video and to provide higher quality images.

The heart of the current DVI system is the i750 Video Display Processor (VDP), a two chip set that includes a pixel processor and an output display processor. Software runs under the MS-DOS operating system as found on a standard IBM PC AT computer and other compatibles. For the potential user, Intel's principal DVI product is the ActionMedia 750 Application Development Platform. It features a DOS-based, 25 MHz, 386 microprocessor and comes with the boardset required to digitize and playback audio and full-motion video pre-installed.

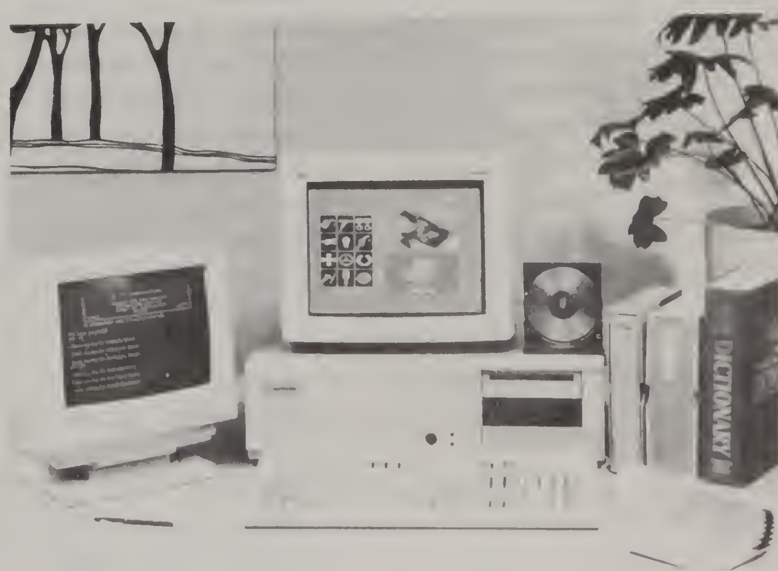

Figure 9. Application Development Platform for DVI Technology (Courtesy of Intel Princeton Operation, DVI Technology)

The DVI "end-user system" includes a PC/AT or compatible computer, an analog RGB super VGA compatible monitor, stereo audio amplifier and speakers, a CD-ROM drive, a keyboard or other input device, and other specialized electronic components.

A recent improvement in the system software provides real-time video compression at 30 frames per second. Called RTV (for real-time-video) version 1.5, this software enables instructional program developers to preview video footage during development and capture (digitize) desired segments in real time. Thus RTV can be used as an authoring tool and the video it delivers is described as "near VCR" quality. If higher resolution is needed, as it is in medical teaching applications, this can be provided through off-line processing at Intel's compression facility (see Chapter Four for additional details).

Another of the intriguing aspects of digital multimedia development is the wide range of options available in respect to audio and visual information quantity and quality. Three levels of audio quality and three levels of still image quality are available. A "mix-and-match" example shows that one DVI CD-ROM disc can provide 20 minutes of full motion video, 5000 high resolution stills, 6 hours of still-frame audio, and 15,000 pages of text. The maximum resolution for DVI video stills presently is 1024 by 512 pixels.

Intel has established a number of DVI Beta test sites at which participating organizations are currently experimenting with the technology and its application to various problems. Intel has also announced a new authoring tool for DVI called Authology: Multimedia. Developed by CEIT Systems, Inc., the system uses a mouse input and a windowing user interface.

Other Optical Disk Formats

Several variations of the audio compact disc have been introduced or announced in the last several years. One, called compact disc-video (CD-V), was introduced by Philips in 1987. It offers 20 minutes of digital audio and five minutes of full-motion, analog video on a standard 4.72" compact disc. Except for its size, however, this is not a <u>true</u> compact disc because it does not follow any of the High Sierra standards. To provide longer playing

times, eight inch (Extended Play) and twelve inch (Long Play) discs were also developed. With the growing popularity of combination videodisc/compact disc players, Philips recently announced that it will no longer use the CD-V name, although the discs will continue to be marketed. In any case, the format is widely regarded as a "music video" medium with little potential for education and training.

Mattel Toys, in 1987, announced a new system that combines interactivity with digital audio and analog video play modes. Called Interactive Compact Video Disc (ICVD), the system is the result of a licensing agreement between Mattel, SOCS Research and Interactive Video Systems, and it is reported to be "a new format separate and distinct from not only conventional CD-audio but laserdiscs as well" (CD-I News, October, 1987, p. 10). Two versions were to be available: A standard CAV play mode providing up to 10 minutes of video and a CLV extended play model for up to 20 minutes of video. At this writing (mid 1990), however, ICVD has not been offered to the public.

Not long ago, the safe prediction would have been that the interactive videodisc, which is an analog device, would remain the most efficient means for educators to provide interactive motion video for instructional purposes for quite some time. But digital technology systems are evolving rapidly, and it appears that they may become practical options sooner than previously expected. Once they do, the important question will be whether they will simply coexist with the videodisc or replace it altogether for multimedia applications.

Recordable and Erasable Optical Disks

Numerous manufacturers, including Panasonic, Pioneer, Sony, and others, now offer recordable optical disk drives that employ the digital technology associated with compact discs. Called WORM drives, for Write-Once, Read-Many, they enable the user to write on the disk as well as read from it. Once written, the data is not erasable. These systems are mainly intended for text and data archives, and most models use a 5.25 inch disk with a capacity that falls in the 200 to 800 megabyte range. Several manufacturers offer a 12 inch disk drive for larger capacity and one, Eastman Kodak, offers a 14

inch size which offers up to 6.8 gigabytes of information storage.

The utility of current "write once" recordable disk systems for maintaining constantly changing files and databases is limited by the fact that information, once recorded, cannot be erased and updated. Thus the erasable disk has for some time been a highly anticipated technical advance, and several erasable or rewritable systems have recently become available.

Advanced Graphics Applications, a New York based firm, developed what Strukhoff (1988, p. 24) described as "the first commercially available erasable optical subsystem." The AGA system uses an Olympus drive and a double-sided, 5.25 inch disk with a total capacity of 650 megabytes. Other firms now marketing rewritable systems include Sony, Maxell, Pinnacle, Sharp, and Verbatim, a Kodak subsidiary. The Verbatim model uses a 3.5 inch disk which holds 60 megabytes of data. However, the 5.25 inch disk appears to be the most widely-used size. Although these disks resemble a compact disc in appearance, they come encased in a hard plastic cartridge and they remain in the cartridge during use.

Figure 10. *An Erasable Optical Disk Drive (Courtesy of N/Hance Systems, Inc.)*

There are, at present, three competing technologies for erasable/rewritable optical disks. Magneto-optical (MO) technology, which employs a laser beam to record and erase information on a thin magnetic film layer on the disk, is the initial leader in the field and its recording process has been standardized under ISO standards. A second rewritable approach is known as crystalline-amorphous or phase-change technology. With this technology, digital information is recorded by using a laser to change the disk's coating from a crystalline to an amorphous state. Phase-change technology is less expensive than magneto-optical and reportedly will be available beginning in 1991.

In 1988, Tandy Corporation announced its intent to develop an erasable/rewritable system that offered complete compatibility with existing CD audio and CD-ROM standards. The underlying technology has been referred to as "thermal optic" and as "dye-polymer" because it employs both thermal and optic principles to allow creation and erasure of nonreflective spots in a dye-polymer layer of the disc (Newsline, 1988, p. 3). This is said to be the least expensive of the three erasable technologies, but, at this writing, no one has offered it to the public.

Erasable and WORM drives, like the basic CD-ROM, are used as computer data storage and retrieval peripherals; however, their distinctive capabilities suggest that each will play a different role in information management. CD-ROM, which serves well as a high-quantity distribution vehicle, is widely regarded as a "publishing medium," whereas WORM units are finding wide application as "archival media." For the obvious reason that their information is changeable, rewritable systems should find a wide range of information storage and distribution uses.

OPTICAL DISC TECHNOLOGY

Record/Play Technology	Electronics Technology	
	Analog (Videodisc)	Digital (Compact Disc)
Indelible Recording --- Read Only	LaserVision (optical reflective) LaserFilm (optical transmissive)	CD-ROM CD-I DVI
Indelible Recording --- Write Once, Read Many	DRAW Systems Optical Disc Corp. Panasonic Sony Teac	WORM Drives (many manufacturers)
Erasable Recording --- Write Many, Read Many	Pioneer/Kokusai Kokusai Denshin Denwa Panasonic LQ-4000	Three Formats magneto-optical phase-change thermal-optic

Figure 11.

III. OPTICAL DISC SYSTEM INTEGRATION

Chapters One and Two presented brief descriptions of technologies now or soon to be available with which optical disc-based teaching systems can be constructed. This chapter examines other factors, both technical and practical, that are relevant to selecting and using such systems in health professions education.

Presently, virtually all optical disc teaching programs in use in health sciences education are of the LaserVision videodisc format. Several manufacturers produce this format, and there are many different individual player models available. One other optical videodisc format is available at the present time, and soon, it appears, at least two major digital (CD) technology systems will become practical options for developing and delivering interactive, multimedia instruction. Thus, although selection options do change as time passes, they seem to remain more than a little complex to the prospective user.

Technology Selection

When purchasing a videodisc system, what you see is only part of what you get. You see an assemblage of electronic components: a player, a monitor, a control device (e.g., a computer), an input device (e.g., a touch screen), and, of course, a disc. But, more than that, each system has distinctive technical features that dictate certain design, authoring and production requirements in creating usable programs. Each disc technology, therefore, should be considered in relation to these requirements, as well as on its technical merits.

Between making the videodisc a major instructional delivery medium--as the US Army reportedly has done --and ignoring it altogether, there are intermediate levels of involvement. Each organization must determine for itself what resources it wishes to commit to acquire the technology and to support its use. One institution may elect merely to experiment with one or two systems, another may decide to build an interactive technology learning resource center as an integral part of its curriculum delivery apparatus. Either way, important choices must be made; choices related to disc technology

format, system integration factors, computer and graphics technology, and authoring tools.

Videodisc Player Options

Activity in the videodisc marketplace over the last several years has resulted in the elimination of several videodisc formats. The Thomson/CSF transmissive optical format and the RCA capacitance electronic disc (CED) disappeared from the market some years ago. The JVC video high density (VHD) capacitance format has been withdrawn from the American market, although, at last word, it is still offered in Europe and Japan. But because the VHD format--according to published sales figures--never enjoyed wide distribution in the United States, even if it were still available it would not be an expedient option in health professions education where acquiring programs in diverse formats is an economic impossibility.

The same comment appears to apply to the McDonnell Douglas LaserFilm system, a transmissive optical format that has been available since 1986. Relatively few have been sold, and thus its future is difficult to predict. Because it is being used in some non health care applications, and because its photographic process reportedly allows for quicker and less expensive disc mastering and duplication, the format may be of interest to some users. Descriptive information is therefore included in this report.

Some developmental work has been done with recordable videodisc technology. Still, the videodisc market, as far as health professions education is concerned, is essentially reduced to one standard--the reflective optical format known by the tradename LaserVision.

LaserVision Format

Because it is the most widely used videodisc technology format in the United States, the LaserVision optical reflective player has earned recognition as "the industry standard," at least for now. Four firms--Pioneer, Sony, Philips, and Hitachi--now command virtually all of the industrial LaserVision player market. In approximate numbers, Pioneer has about two thirds of the market, Sony about one fifth, while the other firms share the

remainder, about thirteen per cent. (For detailed information, see Market at a Glance, 1989.)

As a rule, all videodiscs made to the LaserVision standard play on any player carrying the LaserVision tradename. But this does not mean that any reflective optical videodisc can play on any of the machines available from the firms mentioned above. There are important variations among player models related to the use of audio, video display capability, user interface mode, and control program encoding, storage and retrieval.

The array of videodisc players that the firms mentioned above offer serves to illustrate the wide range of choices available. The Sony LDP-2000 Series, for example, is available in five different configurations to meet different user requirements; still-frame audio and reading digital data from a videodisc are two features that standout among the available options. Another Sony model, the LDP-1200, has a built-in overlay character generator. And Sony has recently brought out a high-definition videodisc player for applications that require higher resolution. Initially priced at about $25,000, it does not play standard LaserVision discs. Pioneer's contribution to the "high-end" videodisc market is called the LD-V8000. Introduced in 1989 at a list price of $2,160, its features include four track audio capability (two analog and two digital), single frame access on CLV discs (which generally has been a feature of CAV discs only), and the ability to display a still-frame while playing any segment of the four audio tracks. Also, in 1989, Pioneer introduced the LD-V2200, a lower cost (list price about $900) player intended for the education market. It features a wireless remote control and RS-232C port for connection to a controlling computer.

LaserFilm Format

The one available optical videodisc format that remains in competition with the LaserVision format is the McDonnell Douglas LaserFilm player. While not widely used in education, it represents an interesting technology approach in that, in contrast to the reflective hard disc that all LaserVision format players use, it employs a transparent, photographic film videodisc. Its video

information is placed on the film disc as a series of dots. Its capacity is 32,400 still frames or eighteen minutes of motion per side. The LaserFilm player, introduced in 1986, has built-in compressed audio capability, a feature that was not common in LaserVision players available at that time. The photographic process makes disc mastering and reproduction relatively inexpensive and rapid for those with access to the necessary equipment. In fact, the idea of "system ownership" by a user organization was a key element of the LaserFilm marketing strategy. Both LaserVision and LaserFilm players can be used as components of prepackaged or "integrated systems" that are now widely available for interactive video applications.

Integrated Interactive Videodisc Systems

One solution to dealing with the varied array of videodisc players and microcomputer products now on the market is to choose one of the integrated videodisc systems which several well-known firms presently offer. In this way the user acquires a "ready-to-run" system and is assured of component compatibility. Compatibility problems still arise <u>among</u> integrated systems because of differences in computer operating systems, in electronic circuitry used to overlay graphics onto video images, and in interface equipment. Thus individual manufacturers have sought to overcome these problems, and gain a marketing edge on their competition, by producing what each sees as the "ideal delivery system" for videodisc instruction.

Figure 12. Authoring with Sony VIEW System (Courtesy of Sony Corporation)

The main ingredients that need to be specified for a "total system" include: 1) the videodisc player (Is a CAV player adequate or is CAV and CLV capability needed?); 2) the computer (Macintosh or IBM or compatible? How much hard disk memory?); 3) audio capability (Is digital sound over still frame required?); 4) the monitor and video or graphic overlay board specifications (One monitor or two? What resolution is needed?); 5) the user input device (touch screen or other?).

When one considers the range of components and specifications that can make up an integrated system, it is easy to see that compatibility is a serious concern. The thrust for standardization among videodisc systems was given considerable impetus when the US Army issued its Electronic Information Delivery System (EIDS) specifications, and awarded a major contract for hardware systems to Matrox Electronics Systems of Canada. These specifications prescribe a front-loading videodisc player with a three second maximum search time and built-in still-frame audio capability, an MS-DOS computer with a 16-bit microprocessor and 256K memory (expandable to 512K), two 3.5 inch disk drives and an RS-232 port. Other operational requirements relative to presentation and feedback management are also specified. As of now, however, the Army's large requirement for these systems seems to have had almost no impact in making the EIDS specification a significant factor relative to technical standards in the field.

Other integrated interactive videodisc systems presently on the market include such well known names as Sony, Pioneer, IBM, Visage, Spectrum, NCR, and OnLine Computer Systems, Inc. IBM's InfoWindow Touch Display System is a touch screen unit that combines an IBM InfoWindow display device, an IBM personal computer (or one of many compatible "clones"), and a LaserVision model videodisc player. Touch screen systems are easy to use and have become a popular option among courseware developers.

The Sony VIEW System, a term Sony has applied to its integrated systems since 1985, is available in several models. The VIW-3015 and VIW-3020, available since 1987, use a Sony SMC-3000V MS-DOS compatible microcomputer and either a Sony LDP-1500 or LDP-

2000 videodisc player to form integrated systems of differing levels of sophistication, depending on the player chosen. The more advanced system provides a still-frame audio option while both systems provide graphics overlay capability. The SMC-3000 computer has two built-in display modes. The high resolution mode provides for display of 256 colors simultaneously, chosen from a palette of 4,096 available colors, with full-screen resolution of 672x496 pixels.

Sony, in 1989, began delivering the VIW-3015A VIEW System which includes VGA standard graphics capability and IBM InfoWindow emulation software. The newest Sony VIEW system is the VIW-5000. It includes a videodisc player, an MS-DOS compatible system controller, built-in CGA/EGA/VGA graphics with IBM InfoWindow video overlay compatibility.

Figure 13. *IBM InfoWindow System (Courtesy of IBM Corporation)*

Pioneer currently markets an integrated system called the LD/VS 1. Its key components are the UC-V102 videodisc controller, the LD-V4200 videodisc player, and a color monitor. The controller can be equipped to control up to five videodisc players. Computer graphics can be superimposed on the videodisc playback signal, and an optional digitizer board provides video signal digitization capability. The controller is equipped with built-in programming capability and includes a keyboard and floppy disk drive.

FITNE System

An interesting example of how a carefully assembled integrated videodisc system can serve a particular user community is illustrated by the FITNE (Fuld Institute for Technology in Nursing Education) Interactive Video System. Designed to provide nursing educators with a common hardware assemblage, the system includes a 286-based computer (IBM AT compatible), a Pioneer LDV-4200 laserdisc player, a touch screen interface and EGA graphics capability. Purchasers also receive emulation software that allows the FITNE system to run programs designed for the IBM InfoWindow Touch Display system. Several other systems among those mentioned above also offer IBM InfoWindow system emulation, an indication that it is becoming a de facto standard for integrated systems.

While the various integrated systems may use similar disc players as their main information source, differences in other components--microcomputers, input devices, graphics devices, and authoring systems--make the choice of an integrated system for educational applications a decision that requires careful analysis. This analysis should also include consideration of educational needs, potential program sources, and "human factors" associated with learner use.

Digital Video

In 1990, we are witnessing the emergence of another disc-based video technology--digital video in the form of CD-ROM XA, CD-I, and DVI. Not long ago, these systems were only laboratory prototypes, essentially representing what one observer has called "a technology, not yet a solution." Whether, and when, these systems might replace the analog, optical videodisc format as the medium of choice for interactive instruction delivery is

one of the more speculative questions in the interactive video field today. But rapid advances in digital technology have brought them much closer to practical reality, to becoming "a solution." Meanwhile, more than a few companies are presently working on either DVI or CD-I applications.

Hardware development for digital video systems seems to be taking two somewhat different paths. CD-I was created as a stand-alone, integrated system consisting of a CD-I player module and a CD-I multimedia controller module. Intel Corporation, on the other hand, describes DVI as an "enabling technology" which it hopes will bring multimedia capability to an array of applications in which a CD-ROM may or may not be used as a storage medium. IBM Corporation has also introduced products which bring multimedia capability to its Personal System/2 family of computers. Thus hardware that provides interactive digital video capability is becoming available, for a price. Software in the form of teaching programs for use in the health sciences, however, is not yet available at any price.

Authoring Tools

The term authoring tools refers to a variety of instructional design and programming aids in two general categories: authoring languages and authoring systems. As the name implies, an authoring language is a computer programming language that has been designed specifically to issue the commands required in interactive courseware design. An authoring system, on the other hand, is a software form that incorporates or "packages" a predetermined set of programming functions and thus essentially eliminates the need for a designer to know computer language programming. The capabilities of available authoring systems vary widely, but the basic idea is to provide the user with the necessary tools--templates, menus, prompts--to facilitate interactive lesson design. A comprehensive authoring system should provide for control of program flow and branching, still-frame and motion video display, analog and digital audio, text and graphic display, and student information collection and record keeping.

Because available authoring software systems vary widely in the features that they offer, there is wide variation in price. The LaserWrite unit from Optical

Data Systems, which Haukom and Malone (1987, p. 105) describe as "a simple, easy to use authoring language for Apple computers," has reportedly sold for as low as $75. Among units in the $5000 range is IBM's InfoWindow Presentation System (IWPS). It consists of two integrated software modules, one an "authoring" program and the other a "presentation" program used to deliver InfoWindow lessons. Other widely advertised systems include IBM's LS/1, Aimtech's IconAuthor system, Computer Teaching Corporation's TenCORE line, Online Computer Systems' OASYS unit, Interactive Technologies Corporation's CDS/Genesis, and Allen Communication's QUEST authoring system. Computer Sciences Corporation markets an authoring system called IV-D and is also the developer of EIDS Assist, the authoring system for the EIDS delivery system. Edudisc Corporation markets a videodisc authoring system called Mentor/MacVideo for use with Macintosh computers. CEIT Systems, the developer of the Authology authoring system, has also introduced Authology: Multimedia, authoring software designed exclusively for the Intel DVI system.

The thrust underlying the development of such systems is to provide tools that can guide the creation of complex interactive lesson designs that may incorporate disc recorded video material, overlaid graphics, graphics animation, dual-track or still-frame audio, information from a peripheral device, such as a CD-ROM drive, and yet be reasonably easy to use. Numerous authoring system producers are claiming success in meeting this challenge, thus making the choice of an authoring system itself a challenge for health professions educators and those who support them in videodisc design activity.

Some authoring system producers claim as an advantage of their product that it offers "portability" among various leading interactive videodisc systems. This means that an interactive program created for a particular integrated system can be "converted" to run on one or more other systems. This feature, of course, can be an important consideration in a field in which programs are to be exchanged among several institutions.

Literature explaining the technical specifications of the various disc players, computers, integrated systems and graphics devices is readily available from the

manufacturers. Some software firms provide authoring system demonstration disks to prospective buyers. Technical specifications, however, should be weighed against the design, authoring, production and program acquisition factors associated with each technology.

IV. OPTICAL DISC DEVELOPMENT

To those with even a modest acquaintance with the process of creating media materials, the words design, development and production are familiar if not altogether differentiating terms. The following excerpt from a 3M company monograph shows that the advent of the interactive videodisc as a teaching tool has added several new terms to the media argot: "The production of optical videodiscs is a demanding and exciting process that requires good teamwork at each stage--from the earliest conception and planning through production to postproduction, premastering and replication" (Premastering, 1981, p. vi). Although it's likely that no one who has gone through this process will quibble with that assessment, the fact that the term "production" is used twice in that sentence, each time with a different meaning, suggests that vocabulary has become something of a problem in the interactive video field.

Development Processes

This chapter, therefore, is a brief attempt, first, to unscramble some of the terminology associated with the creation of optical discs and, second, to examine several major aspects of that process and how they differ for various optical disc formats. To simplify these tasks, the term development, as used in this chapter's title, will be used to signify the entire "demanding process," including the steps outlined above, and more. This process, in turn, will be divided into two major phases: instructional design and production.

Optical Disc Development: Instructional Design

The "earliest conception and planning" phase, a design purist would maintain, should begin with the determination that the teaching-learning problem at hand is in fact one for which interactive video technology is the proper solution. A good place to begin making that determination is with a consideration of interactive video's value as a medium. A major asset of interactive video, Schwier (1987) points out, is that it "capitalizes on the advantages of both video and computer-assisted instruction, and compensates for the weaknesses of each medium" (p. 56).

Video and Computers

The video medium possesses characteristics that are familiar to all; its primary strength is its capability to present realistic motion depictions of events, processes, dramatic simulations, and the like, with great flexibility in varying the images that a viewer sees. Its limitations for instructional purposes are its basically linear nature and the inherent difficulty of providing for learner control and interaction. The computer, as an instructional tool, is an excellent medium for engaging the learner in active participation and giving the learner great flexibility in progressing through instructional programs. Without an accompanying optical disc player, however, its presentation capability has been quite limited. Thus the complementing features of optical disc-based video and computers are readily apparent, and exploiting their combined potential for creating innovative and effective instruction programs ought to be a major focus of videodisc program developers.

Learning Factors

The nature of the content or performance skill to be learned is also a factor to consider early. If the content or skill embodies discrete components around which brief lesson segments can be constructed, interactive video becomes a more attractive option. If the skill involves subordinate elements of varying degrees of difficulty, interactive video becomes even more attractive because it facilitates easy branching to remedial or review segments contained within an instructional sequence. This easy branching feature also allows frequent election of practical exercises within a lesson. The videodisc's flexible and rapid search capability make it ideal for a teaching design in which a number of related lessons are to make up a major module of instruction because, among other advantages, it facilitates the production of a single, comprehensive video demonstration of which designated segments can be accessed with surgical precision for use as specific lesson elements. Schwier (1987, p. 57) also points out that the need for realism in presenting content and the content's "stability" are also factors to be considered. Disc-recorded video can be made to appear very realistic, but videodiscs, once produced, cannot be revised without investing considerable time and money.

Such early planning and decision making can be viewed as a "predesign" activity since the detailed instructional

design process usually begins after the decision to use interactive video has been made. (This is in contrast to "classic" instructional design theory which traditionally maintains that a medium should be selected only after detailed stimulus presentation requirements have been determined.)

Instructional Strategy

In the instructional design stage, an instructional strategy, or set of strategies, is selected and an appropriate lesson structure for implementing the strategy is specified. Then the necessary instructional components, objectives, test items, storyboards, scripts and the like, are prepared. Although this process has much in common with instructional design for other media forms, interactive video typically imposes some special requirements, while offering certain added capabilities. A common requirement with interactive video is to create a flowchart that displays the options and alternative paths through the disc's content that the program design is to afford. Interactive video's added instructional capabilities include its flexibility in mixing and presenting different stimulus forms, in providing diverse testing formats, and in collecting student performance data.

Thus, designing interactive video instruction for any of the existing formats is typically more demanding than designing for traditional media. And, while design activities may not differ significantly from one technology format to another, later production steps normally do, however, as can be seen by comparing LaserVision and LaserFilm disc production and by examining briefly digital video processes.

LaserVision Disc Production

The term production, as used by videodisc producers, commonly refers to the stage in which all source media --filmclips, video sequences, slides, medical images-- needed for the program are shot or acquired. But, in the broader sense used here, production also includes premastering, mastering and replication.

Premastering involves transferring all source materials onto a videotape that meets prescribed standards for tape format, cue insertion, and other technical details required for creating the master disc. Mastering refers

to the next stage in which the master tape--which is sometimes referred to as an edit master or premaster--is used to make the master disc. It is this master disc that is used to replicate all other copies as required by the user. The process by which the information is recorded on a LaserVision format videodisc, in the form of microscopic pits that track from the center to the outside edge of the disc, involves conversion (separately) of the video and audio signals into FM-modulated waveforms, mixing the video and audio signals into a single signal, and using that combined signal to modulate a laser beam which produces the pits in a photosensitive layer of the master disc. During playback, the composite signal needed to produce audio and video stimuli is produced by modulation of the pick-up laser beam by the varying reflection that results from the configuration of the pits on the disc.

LaserFilm Disc Production

The major components of the McDonnell Douglas LaserFilm production system are called the <u>formatter,</u> the <u>recorder,</u> and the <u>autoprinter.</u> The formatter receives source material--video, audio, slides and digital data--and program flow instructions and produces what is called the <u>disc image tape.</u> The recorder uses this formatted disc image tape to produce a <u>master disc</u>. The autoprinter is used to duplicate discs using a photographic process. A printing rate of up to 200 discs per hour is possible, according to the manufacturer, who also claims that duplication costs are lower for this process than for reflective (LaserVision) disc duplication.

Digital Video Production

Again, general instructional design procedures are not greatly affected by the delivery technology. But using digital technology to create interactive video programs --an enterprise that is still in its infancy--introduces significant technical variations, as DVI technology clearly exemplifies.

With Intel Corporation's ActionMedia 750 Application Development Platform, users can create digital-format, interactive video courseware that matches the videodisc in its presentation features using a single, integrated unit. Two "companion boards" within the system make this possible. A "capture board" digitizes and

compresses the input audio and video information and a "delivery board" provides for playback of full-motion video, still images, graphics and audio in an all-digital environment. The new Real-Time Video (RTV) software, mentioned earlier, enables a developer to edit and preview video and assemble a complete application. The resultant database can be stored on the computer's hard disk for playback at 30 frames per second. Developers have the option of using the RTV sequences in the final application, or, if higher quality images are desired, replace them with Production-Level Video (PLV), which is done off-line using powerful, parallel-processing computers at Intel's compression facility. Users send a 1-inch analog videotape master to Intel and get back a digital tape containing a compressed version of their video in which the data per video frame has been reduced from 720 to 4.5 kilobytes, a 160 to one compression ratio. This tape then can be used to transfer the application to a CD-ROM configuration disc, if desired.

Other digital interactive systems, of which CD-I (Compact Disc-Interactive) is perhaps the best known, do differ in their particular configurations and specifications. CD-I has been described as essentially an integrated, stand-alone product for playing interactive CD-ROM-like discs. DVI reportedly grew out of an effort to enhance personal computer functionality by adding the capability to process motion video and high quality audio. But whatever their underlying intent, all professional digital video systems come up against the same technical challenge, providing a signal compression-decompression capability which provides high quality motion and still image display while storing the data files necessary for lengthy programs on a convenient medium such as a CD-ROM disc.

Authoring Optical Disc Programs

The authoring process has not been presented here as a separate stage because typically it comes into play in other stages in ways that vary somewhat with the authoring tool being used. Some comprehensive authoring systems are part storyboarding aid, part production planning tool, and part programming device for the software database that ultimately will run the completed interactive video program. The utility of any particular authoring system depends in large measure on

the programming options it provides related to disc player control, text and graphics display, learner interaction with the program, and learner progress data collection.

Optical Disc Development: A Concluding Comment

Throughout the 1980's, Level III LaserVision videodiscs have strengthened their position as the technology of choice for developing and distributing interactive instructional courseware. In the last half of the decade, three other technological options (not including purely computer-based programs) have appeared as challengers for that particular application. One is the transmissive LaserFilm optical videodisc which was introduced in 1986. It is, by all appearances, still a rare commodity in the health sciences education community. The Level IV videodisc is arguably a distinct option to the Level III disc because of the particular technical and logistical features it embodies. The logistical advantage with Level IV is that no floppy disk is required to carry the program software database because it, like the teaching content, is encoded on the videodisc itself. Thus distribution problems are lessened considerably because there is no added disk to handle and ship to training sites or purchasers. This, however, necessitates encoding the program control data in the disc's video field, and, if compressed digital audio is to be used for still-frame accompaniment (a technique also possible with some Level III players), this data, too, must be placed in the video field. Both of these are delicate production processes which must be done with great care. Not surprisingly, they add to the cost of videodisc development and help explain why few "true" Level IV discs have been made.

The promise and appeal of digital video, however, may make questions about different videodiscs formats irrelevant in the 1990's, at least if the manufacturers and developers of digital systems are able to achieve their goals. There are certain advantages to working in an all digital environment as opposed to designing and producing courseware for mixed analog-digital systems. The central problem that digital video manufacturers are facing is to develop the electronic circuits needed to provide the enormous processing power that providing high quality, full-screen, motion video requires. Intel has stated its expectation to greatly improve video

processing capability for DVI technology in the 1990's, and Philips International recently entered into an agreement with Motorola, Inc. to develop advanced circuits for Compact-Disc Interactive (CD-I) technology. If such efforts succeed in bringing high quality video to microcomputer-based desktop learning stations, the popular videodisc format may be seriously challenged as the medium for interactive video applications during the 1990's.

The next few years should see substantial progress in answering several basic questions about the future of optical disc technology. Will the Level IV videodisc ever become a viable technology in professional education? Will transmissive film discs ever find a place in the videodisc market? Will any analog videodisc format survive in a world that seems to be going all digital? The expression may be overused, but the advice is still sound: Stay tuned!

REFERENCES

American Interactive Media titles in production. (1989, June). The Videodisc Monitor, pp. 4,5.

CD-I News. (1987, October). Author.

Hannafin, M.J. (1985). Empirical issues in the study of computer assisted interactive video. Educational Communication and Technology Journal, 33, 235-247.

Haukom, R., & Malone, E. (1987). A survey of level III videodisc delivery systems. In S. Lambert & J. Sallis (Eds.), CD-I and interactive videodisc technology (pp. 93-115). Indianapolis: Howard W. Sams.

Howsie, P. (1987, July). Adopting interactive videodisc technology for education. Educational Technology, pp. 5-10.

Jarvis, C.S. (1988,May). 1988: The 30th anniversary of the videodisc. The Videodisc Monitor, p. 15.

Joint development yields rewritable "laserdisc." (1989, November). The Videodisc Monitor, pp. 1,3.

LaserLearn Report. (1987, September). Hane Industrial Training.

Mann, C.C. (1981, October/November). How it works: Videodisc. Technology Illustrated, pp. 102,103.

Market at a glance. (1989, June). The Videodisc Monitor, p. 28.

Newsline. (1988, May). The Videodisc Monitor, p. 3.

Panasonic announces rewriteable videodisc recorder. (1990, May). The Videodisc Monitor, p. 1.

Premastering/Post Production Procedures. (1981). St. Paul, MN: Minnesota Mining and Manufacturing Company.

Rice, P., & Dubbe, R. (1982). Development of the first optical videodisc. SMPTE Journal, 91, 277-284.

Sayers, J. (1987, January/February). Optical disc cornucopia. Medical Disc Reporter, p. 4.

Schwier, R. (1987). Interactive Video. Englewood Cliffs, N. J.: Educational Technology Publications.

Strukhoff, R. (1988, September). Getting the whole picture. CD-ROM Review, pp. 24-26.

APPENDIX

Selected Information Sources on Interactive Technology

Associations

Association for the Development of Computer-Based Instructional Systems (ADCIS).
The Ohio State University
229 Ramseyer Hall
29 West Woodruff
Columbus, Ohio 43210

Association for Educational Communications and Technology (AECT)
1025 Vermont Avenue, N.W.
Suite 820
Washington, D.C. 20005

Health Sciences Communications Association (HeSCA)
6105 Lindell Blvd.
St. Louis, MO 63112

International Interactive Communications Society (IICS)
2298 Valerie Court
Campbell, CA 95008

Periodicals: Specific to Interactive Technology

CD-I News
Emerging Technologies Publications
LINK Resources Corporation
79 Fifth Avenue
New York, NY 10003

CD Publisher News
Meridian Data, Inc.
4450 Capitola Rd., Suite 101
Capitola, CA 95010

Interact Journal
International Interactive Communications Society
c/o Applied Learning
1751 Diehl Road
Naperville, IL 60563

Interactive Healthcare Newsletter
Stewart Publishing, Inc.
6471 Merritt Court
Alexandria, VA 22312

Journal of Computer Based Instruction
ADCIS, The Ohio State University
229 Ramseyer Hall
29 West Woodruff
Columbus, Ohio 43210

Journal of Interactive Instruction Development
50 Culpeper Street
Warrenton, VA 22186

The Videodisc Monitor
Post Office Box 26
Falls Church, VA 22046

Periodicals: General Educational Technology

Educational Technology Magazine
720 Palisade Avenue
Englewood Cliffs, NJ 07632

Instruction Delivery Systems
50 Culpeper Street
Warrenton, VA 22186

Tech Trends
AECT
1025 Vermont Avenue, N.W.
Suite 820
Washington, D.C. 20005

T.H.E. Journal
Information Synergy Inc.
2626 S. Pullman
Santa Ana, CA 92705

Videography
P.S.N. Publications, Inc.
2 Park Avenue, Suite 1820
New York, NY 10016

Books

Ambron, S., and Hooper, K. (Eds.) (1988)
Interactive Multimedia
Microsoft Press
Redmond, Washington 98073

Arwady, J. and Gayeski D. (1989)
Using Video: Interactive and Linear Designs
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, New Jersey, 07632

Crowell, P. (1988)
Authoring Systems
Available from Future Systems, Inc.
P.O. Box 26
Falls, Church, VA 22046

DeBloois, Michael L. (1982)
Videodisc/Microcomputer Courseware Design
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, NJ 07632

DeBloois, Michael L. (1988)
Use and Effectiveness of Videodisc Training
Future Systems, Inc.
P.O. Box 26
Falls Church, VA 22046

Haynes, George R. (1989)
Opening Minds: The Evolution of Videodiscs and Interactive Learning
Kendall/Hunt Publishing Company,
Dubuque, Iowa 52004

Iuppa, Nicholas (1984)
A Practical Guide to Interactive Video Design
Knowledge Industry Publications
701 Westchester Avenue
White Plains, NY 10604

Iuppa, Nicholas, and Anderson, Karl (1987)
Advanced Interactive Video Design
Knowledge Industry Publications
701 Westchester Avenue
White Plains, NY 10604

Jonassen, D. (1989)
Hypertext/Hypermedia
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, New Jersey 07632

Jones, M. (1989)
Human-Computer Interaction: A Design Guide
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, New Jersey 07632

Lambert, Steve, and Sallis, Jane (Eds.) (1987)
CD-I and Interactive Videodisc Technology
Howard W. Sams & Co.
4300 W. 62nd Street
Indianapolis, Indiana 46268

McFarland, T., and Parker, R. (1990)
Expert Systems in Education and Training
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, New Jersey 07632

Philips, International, Inc. (1988)
Compact Disc-Interactive: A Designer's Overview
Available From Future Systems, Inc.
P.O. Box 26
Falls Church, VA 22046

Schwartz, E. (1987)
The Educator's Handbook to Interactive Videodisc
AECT
1025 Vermont Avenue, N.W.
Suite 820
Washington, D.C. 20005

Schwier, Richard (1988)
Interactive Video
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, NJ 07632

Souter, Gerald A. (1988)
The DISConnection: How to Interface Computers and Video
Knowledge Industry Publications, Inc.
White Plains, NY 10604

Industry Guides

The Complete Interactive Video Courseware Directory
Convergent Technologies Associates
97 Devonshire Drive
New Hyde Park, NY 11040

Videodiscs in Healthcare (1990)
Stewart Publishing, Inc.
6471 Merritt Court
Alexandria, VA 22312

Training Resource Organizations

Bloomsburg University, Bloomsburg, PA 17815
(Instructional Technology Degree Program)
(Interactive Video Workshops)
Contact: Dr. Harold Bailey

Nebraska Videodisc Design/Production Group
(Annual Symposium and Videodisc Workshop Series)
KUON-TV, University of Nebraska
Lincoln, NE 68501

Society for Applied Learning Technology (SALT)
(Conferences and Tutorial Sessions)
50 Culpeper Street
Warrenton, VA 22186

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	[illegible], Daniel A. (1980) The Videodisc Book: How to Interface Computers and Video Knowledge Industry Publications, Inc. White Plains, NY 10604
Industry Guides	The Optical Interactive Video Courseware Directory Conceptual Technologies Associates 97 Dunwoodie Drive New Hyde Park, NY 11040
	Videodiscs in Healthcare (1980) Stewart Publishing, Inc. 6471 Merritt Court Alexandria, VA 22312
Training Resource Organizations	Bloomsburg University, Bloomsburg, PA 17815 (Instructional Technology Degree Program), (Interactive Video Workshops) Contact: Dr. Harold Bailey
	Nebraska Videodisc Design/Production Group (Annual Symposium and Videodisc Workshop Series) KUON-TV, University of Nebraska Lincoln, NE 68501
	Society for Applied Learning Technology (SALT) (Conferences and Tutorial Sessions) 50 Culpeper Street Warrenton, VA 22186

The Learning Center
For Interactive Technology

Educational Technology Branch
Lister Hill National Center for Biomedical Communications

For information and tour appointments:

Write: Coordinator
The Learning Center for Interactive Technology
Lister Hill National Center for Biomedical Communications
National Library of Medicine
Bethesda, Maryland 20894

Phone: (301) 496-0508 General inquiries
(301) 480-3035 FAX
(301) 496-0807 TDD (Auto answer)

Electronic Mail: EasyLink, Telemail, MCI Mail -- TWX (710) 824-9615
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